
# D5.4: Final report on the correlation between energy efficiency and probability of default

# Executive Summary

This report summarises the results of several empirical and econometric studies investigating the relationship between credit risk and the energy performance of buildings used as collateral in commercial and residential mortgages. Many of these studies are first of their kind to address this topic in the European markets. The table below is the summary of the main findings.

**Table 1. EeMAP Findings Summary Table**

| Country | Scope | Main Findings | Energy Performance Criteria | Data Source | Reference |
|---|---|---|---|---|---|
| **Belgium** | Residential | Negative correlation – mortgages on energy efficient properties are correlated with lower risk (measured by PD survival rates) | Loan eligibility for 2009-2011 Government retrofitting programme (dummy variable) | Proprietary bank data on loan type and origination date | EeMAP Technical Report D5.3 |
| **Germany** | Residential | Inconclusive – the absence of default data in the sample prevents any analysis or hypothesis testing. | Municipality and year of introduction of the “Passiv House Standard” | Building’s construction year and zip code information | EeMAP Technical Report D5.2 |
| **Italy** | Residential | Inconclusive – It has not been possible to merge the building-level information one-to-one with the anonymised loan-level data for data privacy regulations issues | Government EE financing programme (dummy variable) | ENEA – Italian Energy Agency data and anonymized loan-level banking information | EeMAP Technical Report D5.3 |
| **Netherlands** | Residential | Negative correlation – Mortgages on energy efficient properties are correlated with lower risk (measured by PD survival rates) | EPC ratings | RVO Energy Agency | EeMAP Technical Report D5.3 |
| **United Kingdom** | Residential | Negative Correlation – the share of borrowers in mortgage arrears is significantly lower for energy-efficient properties. | EPC rating (score divided in terciles[1] for a “best in class” indicator) | EHL; DCLC | Guin and Korhonen (2018) |
| **United States** | Residential & Commercial | Negative – The findings suggest that ENERGY STAR-labelled commercial buildings are 20 percent less likely to default than their non-labelled counterparts. | Green building Certifications & labels (LEED, ENERGY STAR, BREEAM, HQE) | Loan level information coupled with ENERGY STAR and Credit score ratings | Kaza, Quercia, and Tian (2014), An and Pivo (2015) |

[1] Three equally distributed groups, first group representing the first 33.33% of the sample, the second 66.66% and the third the “best in class” 33.33%

**DISCLAIMER** – While these reports are highly original, the datasets and models employed to link loan level financial performance data with energy efficiency criteria are not flawless but make use of any information available and accessible at the time of investigation. These have been extensively discussed in the previous EeMAP technical reports[2] and are due primarily to availability of data (short data history) and accessibility, especially of loan-level energy efficiency information.

**FINDINGS –** The reports suggest there is a link between the energy performance of buildings and credit default risk regardless of whether energy efficiency is captured via individual energy performance labels or proxies such as property types and construction years. Among the countries investigated by the EeMAP consortium (Belgium, Germany, Italy, Netherlands, UK), several indicate negative correlation between energy performance and risk, meaning that, all else being equal and controlled for, energy efficient mortgages and loans appear to be less risky than their non-energy efficient counterparts. The findings for Belgium and the Netherlands are, in particular, highly significant. Results in Germany and Italy were inconclusive, but neither do they prove the contrary. Existing literature and further studies are as well aligned with these research findings and pave the way for further empirical and econometric analyses.

**RECOMMENDATIONS & NEXT STEPS** – While in many cases the reports suggest a correlation between building energy performance and lower credit risk, at the same time, a correlation cannot be concluded only by looking at one-time snapshots of narrowly defined market segments. By way of the proposed standardised data collection framework to be delivered under the Energy Efficient Data Protocol & Portal (EeDaPP), it will be possible to develop a more systematic approach to capturing and monitoring the risk profile of energy efficiency mortgages. Further studies could also go a step further and eventually test for causality not just correlation, however this will require longer track record of loan level data and full transparency to the energy performance of assets.

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[2] Available here: https://eemap.energyefficientmortgages.eu/04-downloads-2/

EeMAP
Energy efficient Mortgages Action Plan

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# 1. Introduction

The EeMAP project, a market initiative funded by the H2020 programme, aims to develop a European market for energy efficient mortgages. The initiative works on the premise that loans secured on buildings which have high levels of energy efficiency have a risk mitigation effect for lending institutions. This is as a result of its impact on a borrower's ability to service their loan and on the value of the property. This means that energy efficient mortgages should represent a lower risk on the balance sheet of banks and could, therefore, qualify for a better capital or interest treatment.

The present report is the final analysis of the EeMAP consortium on the correlation between energy efficiency and default probability. It concludes two years of research by presenting the outcome of two workstreams:

- Literature review of published sources
- Own modelling and statistical analysis of portfolio and bank level data

This report is one of the first to review the empirical evidence base across European countries, using loan level banking data matched with energy performance indicators based on EU and national policies.

The report is divided into three chapters: The first chapter is a summary of previous EeMAP publications that detail scope, the choice of research questions and methodology used. The second chapter reviews the main results obtained by the statistical and econometric research carried out by the EeMAP Consortium using exclusive bank level datasets obtained in four European countries and the United Sates. The final chapter complements the correlation analysis by relating energy performance and efficiency gains with further microeconomic indicators which have a likely impact on the probability of default.

# 2. Review of earlier EeMAP resources

## 2.1 Common data challenges related to linking energy efficiency and default risk

A preliminary evaluation of the impact of energy efficiency on probability of default was published in October 2017.[3] The review of existing literature revealed that academics face several challenges when studying the impact of energy performance on the risk profile of (a) the borrower and (b) the collateralised real estate asset itself. The main challenges are:

- **Data access:** bank portfolio analysis involves highly sensitive data which relate to core business strategies of banks (risk mitigation). Loan level datasets necessary to conduct default probability models are handled usually by banks' risk departments. Neither this data, nor the results of internal risk models and their methodology, are easily accessible to external research teams.

- **Data availability:** data related challenges should not be looked at in isolation, as most of them are inter-dependant and linked, such as data availability, access, storage, reporting and quality. Still, one of the most prominent challenge in the residential real estate sector is data availability. In addition, heterogeneity of property makes comparing energy performance difficult. There are many variations in the way that energy data is captured and assessed as EPC methodologies varies from country to country and in some cases within countries. Even where there is a nominal consistency between the measures, there may still be issues around accuracy and relationship with actual energy performance.

These barriers are both symptomatic of the broader issue that the loan-level tagging of property information, including that of the energy efficiency characteristics, requires an overhaul of banks' and lending institutions' IT reporting infrastructure which heavily impacts the entire mortgage value chain from origination (i.e. the increase the level of data fields required at the issuance of a new mortgage) to risk management and funding (i.e. identifying and tagging all relevant loans from the balance sheet and link it with energy performance indicators). Currently, banks and lending institutions do not yet have sufficient incentives to invest in data collection, management and sharing processes of this nature.

[3] Available here: https://eemap.energyefficientmortgages.eu/wp-content/uploads/2018/04/EeMAP-Technical-Report-on-the-Impact-of-Energy-Efficiency-on-Probability-of-default.pdf

## 2.2 Research questions and methodological choices

The EeMAP D5.2 report published in February 2019[4] presents a methodology to link energy efficiency to probability of mortgage default. The report laid down the theoretical premises to analyse the correlation and defined the research questions and working hypotheses that shall consequently be tested empirically.

**Correlation vs Causality**: in the research world, there is a significant difference between correlation and causality. Correlation analysis is studying the relationship between two events. Causality, or causation, shows that one variable directly affects a change in the other. Although correlation may imply causality, the proof of correlation needs to be completed by a causality test to conclude that there is a cause-and-effect relationship. Causality investigation is, from an academic point of view, the next step of the study and remains an aspirational step that highly depends upon data availability and granularity. Unfortunately, as mentioned in previous publications, the lack of a comprehensive track record for energy performance monitoring of properties at loan level prevent, for the time being, prevent researchers to perform causality investigations. Such studies would require longer data history spanning over a couple of economic cycles. The energy performance legislation and certification are relatively new developments compared to the required time series data.

Nevertheless, the results presented in this report make use of rich databases comprising longitudinal data that can capture both time (economic and financial cycles) and cross-sectional variation which is a sound basis to carry out a comprehensive correlation analysis. The investigation has moreover used all valuable cross-sectional information available to control key factors such as regional differences; income levels (which is known to be correlated with household's energy demand) and relevant socio-demographic characteristics.

**Real energy performance matching vs modelled performance information:** Ideally, the analysis and empirical study would have investigated the direct, loan-level relation between the *actual* energy efficiency of a property and its underlying credit default risk parameters. Given the current lack of energy efficiency data at loan-level data, proxies and models had to be used to estimate the energy performance of collateral property at aggregated levels, using for example property types and construction years.

**Choice of dependent variables and proxies:** Deriving from the key methodological choices and data availability**,** the analysis uses the Probability of Default as the main dependent variable. Other credit default risk-derivable indicator used is the duration (in days or months) before default.

[4] Available here: https://eemap.energyefficientmortgages.eu/wp-content/uploads/2019/02/EeMAP_D5.1_EMF-ECBC_Final.pdf

## 3. Country breakdown of research findings

To assess whether energy efficient properties, when financed and secured in a bank's balance sheet, are less risky than their less efficient counterparts i.e., properties that share the same attributes but have a lower energy performance, the EeMAP Consortium carried out statistical and econometric research by using exclusive bank level datasets obtained in four European countries and the United Sates[5]:

### 3.1 Belgium

The Belgian market was analysed using proprietary loan-level data received from an EeMAP pilot scheme bank. The dataset covers loans that were issued by the bank between 2009 and 2011. As described in the EeMAP D5.1 technical report, this time span corresponds to the period when the Belgian government encouraged and subsidised energy-saving investments for housing improvements through a temporary "green loan" initiative.[6] The subsidies included both lower interest rates and tax incentives. During this period, the Belgian bank originated comparable loans that could be screened and differentiated against the eligibility of these fiscal subsidies. The focus is on consumer and home loans only, whereby the building has to be the borrower's main residence in order to ensure that the borrower actually occupies the building.

After cleaning the data of outliers, the final dataset yields 42,055 individual loan entities. The main advantage of using this dataset is that the loan components that are relevant for the analysis, such as borrowers' demographics, mortgage information, and buildings' renovation purpose, are already linked to each other. Furthermore, the data are available as a cross-sectional snapshot of the bank's loan portfolio as of November 2018, which means that the loans are sufficiently mature to incur defaults.

The EeMAP D5.2 and D5.3 technical reports conducted both descriptive statistic and logistic regressions. Differences between borrowers of energy efficiency and non-energy efficiency loans can be observed, for instance, borrowers of energy efficiency loans are typically younger, earn more, live in more expensive dwellings, and take less debt than their non-EE counterparts.

The correlation analysis controls for such borrower- and building-specific differences in order to reduce confounding of results. The logistic regression estimates indicate a significant and robust positive correlation between taking a loan for energy efficiency renovation purposes and the less

[5] Available here for D5.2: https://eemap.energyefficientmortgages.eu/wp-content/uploads/EeMAP_D5.2_UNIVE_Final.pdf and D5.3: https://eemap.energyefficientmortgages.eu/wp-content/uploads/EeMAP_D5.3_UNIVE_Final.pdf

[6] For further information, refer to Hoebeeck and Inghelbrecht (2017) and e-Justice Belgium (http://www.ejustice.just.fgov.be/cgi/article_body.pl?language=nl&caller=summary&pub_date=09-07-31&numac=2009003261)

likelihood of defaulting on debt payments.

## 3.2 Italy

Two enquiries were carried out in Italy which both employ regional- and provincial-level energy efficiency information. The details of these analyses are outlined in the EeMAP technical reports D5.1 to D5.3.

In the case of the regional analysis, tax rebate records on energy efficiency retrofitting were used in 20 Italian regions. Loan-level data was coupled with this energy efficiency proxy to study the relation between energy efficiency investments and regional mortgage defaults. The findings indicate that regions with higher government energy efficiency spending are associated, on average, with lower individual mortgage default rates.

The provincial analysis focuses on the Lombardy region as it provides open access to energy efficiency information. This dataset is used to build various proxies of energy efficiency per province in order to study the relation between province-level energy efficiency improvements and the mortgage default risk. As reported in D5.3, the empirical findings are inconclusive as the results lack significance.

Both analyses only provide a high-level snapshot of the relation between energy efficiency and credit risk as a granular, loan-level analysis is not feasible with the data available. In particular, it has not been possible to fully exploit the potential of the very granular dataset provided by the region Lombardy. The reason for this comes from data privacy regulations: it is currently impossible to merge the building-level information one-to-one with the anonymised loan-level data from data providers such as European DataWarehouse as neither house numbers nor street names are provided in the latter dataset. However, this obstacle could be easily overcome if the mortgage-issuing banks would collect and store energy efficiency data at loan origination.

## 3.3 Netherlands

D5.1 to D5.3 technical reports also examine the Dutch mortgage market. The data sample focuses on residential buildings and consists of mortgages issued against more than 120,000 dwellings. This dataset has been appended with provisional energy efficiency ratings that are assigned by the Netherlands Enterprise Agency (Rijksdienst voor Ondernemend Nederland, in short RVO) to all Dutch buildings that are not yet supplied with the actual energy performance certificate (EPC) rating. RVO provides rating categories for 60 pairs of different building types and construction period combinations in the Netherlands. This allows matching the mortgage data with energy efficiency ratings using building type and construction year as proxies.

Additionally, we exploit the fact that the ratings change asynchronously across the different building types in order to disentangle the energy efficiency-component from building type- and building age-specific effects that are typically associated with borrower's risk of default.

The reports employ two different empirical methodologies – the logistic regression and the extended Cox model – and find that energy efficiency is negatively related with a borrower's likelihood of default on mortgage payments. The findings survive a series of robustness checks. The results hold even when controlling for borrower, mortgage, and market control variables.

As an additional task, the reports investigate to what extent the degree of energy efficiency plays a role in borrower's credit risk profile. The findings suggest that mortgages issued against more efficient buildings are less prone to default. However, the results are to be balanced with the inherent lack of accuracy when using proxies to match mortgage data and building performance.

## 3.4 The United Kingdom

In the UK, the English Housing Survey collects household, building and mortgage information, which was used to analyse the relationship between energy efficiency and mortgage default risk. As described in the technical reports D5.1 and D5.2, the survey provides details on the mortgage repayment status of households and the energy efficiency rating of the dwellings, which enables a credit risk analysis.

The logistic regression results presented in D5.3 provide an inconclusive picture; the findings indicate a negative correlation between the two variables of interest, but they lack any significance. This outcome can be attributed to the relatively small sample size of around 4,700 observations.

An analysis of a much larger dataset was recently performed by Guin and Korhonen (2018). The authors use in their regression analysis more than 1.8 million residential mortgages matched with the EPC information on the underlying properties. Their findings indicate that the energy efficiency of a property is a relevant predictor of mortgage risk; the correlation between a building's energy efficiency and a borrower's risk of going into arrears is negative and statistically significant.

## 3.5 The United States

The EeMAP project did not conduct any original empirical studies in the US market. There has been some research examining the relationship, if any, between a property's energy label and the probability of default.

An and Pivo (2015) performed an analysis of the relationship between energy efficient buildings which hold an ENERGY STAR label, and the corresponding commercial mortgage default risk. The underlying loan sample is comprised of about 23,000 commercial mortgages that were originated between the years 2000 and 2012 in 17 Metropolitan Statistical Areas in the United States. The authors employ a standard Cox proportional hazard model and provide evidence that traditional default predictors do not fully reflect the financial benefits of energy efficiency. The findings suggest that ENERGY STAR-labelled commercial buildings are 20 percent less likely to default than their non-labelled counterparts. However, one should be cautious to generalise these findings since only a small fraction (3.3%) of all loans in the sample is ENERGY STAR-rated.

Kaza, Quercia, and Tian (2014) also investigated the relationship between energy efficiency and the probability of default of residential mortgage loans. The authors employ information on about 71,000 loans for single-family, owner-occupied houses. The loans were originated between the years 2002 and 2010 in the United States and were used for purchase only. In the sample, all loans are accompanied by a HERS index score and about 35 percent of the houses are ENERGY STAR-certified. The authors employ a hazard analysis and find that ENERGY STAR-rated houses are associated with a substantial and significant reduction of default and prepayment risk.

Other things equal, the results suggest that the probability of default of an ENERGY STAR-rated dwelling decreases by roughly 20 percent compared to a similar but non-rated house. In an additional analysis, the authors consider ENERGY STAR-certified homes only and examine the relative impact of energy efficiency on mortgage risk by utilising the HERS index information. The findings suggest that the degree of energy efficiency plays a substantial role: a marginal decrease in the HERS index implies a significant reduction in the likelihood of loan default. These findings suggest that even among ENERGY STAR-rated buildings differences prevail with mortgages on most energy efficient homes being the least likely to default. However, this evidence should be viewed with a certain amount of caution since the model may suffer from endogeneity issues. For instance, mortgage borrowers residing in energy-efficient dwellings may be financially better-off than those with less efficient properties. Furthermore, the authors employed a partially representative sample as important states, such as California, were excluded due to lack of data.

# 4. Complementary Studies

This last section of this report displays food for thoughts for next researches as the demand for substantial and empirical evidence for the correlation and, in time, the causality between energy efficiency and risk is increasing from both the private and the public side of capital markets and within the banking industry.

## 4.1 The impact of energy performance on income and energy savings

As discussed in the previous section of this report, portfolio assessments are the straightforward way to assess the potential impact of energy performance on risk. These would commonly consider the correlation at loan level between:

- Probability of Default or Loss Given Default as defined in the Internal Rating Based (IRB) models, and
- the energy performance of the underlying collateral as captured by individual EPC ratings or other proxies such as building type and age

This correlation analysis however can be enriched by relating energy performance and efficiency gains with selected microeconomic indicators which thought to have an impact on the risk profile and the likeliness of default. Given the impact of energy efficiency on both capital stock and cash-flows, the following indicators can be considered:

- Disposable income (value)
- Income decile (distribution)
- Housing costs
- Energy Prices
- Property value

The LENDERS[7] project has demonstrated a significant variance between fuel costs and actual fuel bills which can have an impact on the affordability of mortgages. The tables from below illustrate that there is a quantifiable relationship between home occupancy, home energy efficiency and the household's expenditure on fuel. The findings of LENDERS suggest that there are likely to be opportunities for mortgage lenders to improve the accuracy of the data that they use when assessing affordability to more closely reflect the actual energy performance of a home and its occupants.

Similar studies have been carried out in other countries attempting to quantify the monetary gains from energy efficiency measures. As a caveat, however, all these studies point out strongly their findings are theoretical and based on assumptions about the preferences and expectations of a

[7] http://www.epcmortgage.org.uk/ and Report accessible online at https://eemap.energyefficientmortgages.eu/wp-content/uploads/2018/04/Lenders-Project.pdf

rational buyer, which would need to be checked against larger scale empirical evidence. Care needs to be taken also to recognise that there is no clear-cut equation between energy efficiency measures and house price rise. Although certainly there is a connection, it is not necessarily linear or inevitable.

Nevertheless, the findings presented in these studies give a consistent and very close interval benchmark across several European countries with various climate and policy and energy landscapes. Almost all provide observational evidence of a positive link between levels of energy efficiency, normally measured in terms of the EPC, and transacted prices (rental or capital). They collectively provide strong trend data; however, they do not explain why such value differentiation is occurring, nor can they give evidence to adjust property values. Danish and Italian studies show that, under fixed retail energy costs, the annual energy expenditures to homes similar in sizes and types are 6 times lower in highly energy performant homes (i.e. A labelled housing) than in their least efficient (i.e. G labelled) counterparts. According to annual energy costs derived from fixed regulated prices at retail levels, all studies estimate there is a substantial monetary gain from energy efficiency. For example, in the UK annual energy bill reductions range from 90£ (moving from G to F in a flat) up to 1290£ (moving from G to A).

**Table 2. Estimated energy savings and market value appreciation in the Danish residential sector**

| EPC Label | Energy Consumption (kWh/m²/y) | Energy costs* (€/year) | Estimated Energy Savings from class G (€/year) | Additional Market Value from Class G (€) |
|---|---|---|---|---|
| A | 55 | 600 € | 3.050 € | 64.000 € |
| B | 81 | 850 € | 2.800 € | 58.000 € |
| C | 117 | 1.250 € | 2.400 € | 50.000 € |
| D | 167 | 1.800 € | 1.850 € | 38.000 € |
| E | 217 | 2.400 € | 1.250 € | 27.000 € |
| F | 274 | 3.000 € | 650 € | 14.000 € |
| G | 335 | 3.650 € | - € | - € |

*Source. Copenhagen Economics (2015) (*average energy price of 0,10€ per kWh and considering a 100m² house)*

**Table 3. Estimated energy savings and market value appreciation in the Italian residential sector**

| EPC Label | Energy Consumption (kWh/m²/y) | Energy Savings from class G | Energy Costs (€/m²/year) | Energy Savings per year from G label (100m² house) | Additional Market Value from Class G (100m² house) |
|---|---|---|---|---|---|
| A | 30 | 170 | 5 € | 2.550 € | 53.100 € |
| B | 50 | 150 | 8 € | 2.250 € | 46.900 € |
| C | 70 | 130 | 11 € | 1.950 € | 40.600 € |
| D | 90 | 110 | 14 € | 1.650 € | 34.400 € |
| E | 120 | 80 | 18 € | 1.200 € | 25.000 € |
| F | 160 | 40 | 24 € | 600 € | 12.500 € |
| G | 200 | 0 | 30 € | - € | - € |

*Source: ENEL and Nomisma (2018)*

**Table 4. Estimated energy savings for single houses and collective dwellings in the UK**

| EPC Label | Annual Energy Costs | Annual Energy Savings from G label (Flat) | Annual Energy Savings from G label (house) |
|---|---|---|---|
| A | £ 400 | £ 1.290 | £ 1.744 |
| B | £ 706 | £ 984 | £ 1.331 |
| C | £ 985 | £ 705 | £ 953 |
| D | £ 1.173 | £ 517 | £ 699 |
| E | £ 1.428 | £ 262 | £ 354 |
| F | £ 1.615 | £ 75 | £ 101 |
| G | £ 1.690,00 | £ - | £ - |

*Source: Lenders Project*[8]

## 4.2 The financial viability of energy efficiency investments

Relevant to the scope of this report, the payback period and financial viability of energy efficiency measures is expected to have an impact on the repayment capacity of the loan and the probability of a default. An energy efficiency investment financed by a banking loan is more likely to be repaid in time and in full if the return on investment is positive.

Improving energy efficiency can entail the use of a wide variety of technologies. Most practicable energy efficiency upgrades fall within one of three categories: lighting systems, building envelope and mechanical systems. Current technologies in all three categories can provide significant efficiencies, but there are limits to what they can achieve alone.

Lighting ranks probably the highest in terms of cost/kWh energy saved, has a low installation/ongoing disruption and payback time under a year, however it will contribute little to reducing the overall energy consumption of the building. In contrast, in the appropriate climate, improving the building envelope can improve energy performance by as much as 70%— but payback could be very long (beyond 35 years). Even the simplest attempt to reduce thermal bridging in the building envelope, such as adding insulation or improving glazing, can be expensive. Mechanical (e.g. HVAC, building control) upgrades are placed usually somewhere in the middle of the rank in terms of upfront investment and achieved savings.

When calculating the viability of any intervention, it is important to have a life-cycle approach to consider all the costs and savings to allow a thorough comparison to take place. These will typically include costs for construction, operation, maintenance, replacement and disposal, as well as income from sources such as export tariffs or "roof rentals". During renovations, the assessment of total costs

[8] http://www.epcmortgage.org.uk/

is further complicated by the difficulty to detangle the measures that are exclusively dedicated to energy efficiency and other necessary costs that would have been necessary to spend in a renovation process that wouldn't include energy efficiency measures. Equally, visible components (such as improved glazing) that in themselves contribute to energy efficiency may be more influential in terms of value determination than less visible interventions.[9]

Taking all the above into consideration means that retrofitting the existing building stock to rigorous net-zero standards is a very ambitious undertaking, especially if the starting point is a relatively low overall performance. This has also been recognised by the Energy Efficient Mortgages definition which requires a 30% relative improvement in performance to be considered for an EEM. Reaching net-zero will not happen simply by piling on new technologies. The right strategies must be determined according to climate, construction and building type, but also the financial viability of these interventions. The EEMI valuation checklist[10] aims to provide additional information about the individual building characteristics and interventions which impact more readily on energy efficiency but also property value and risk of obsolescence.

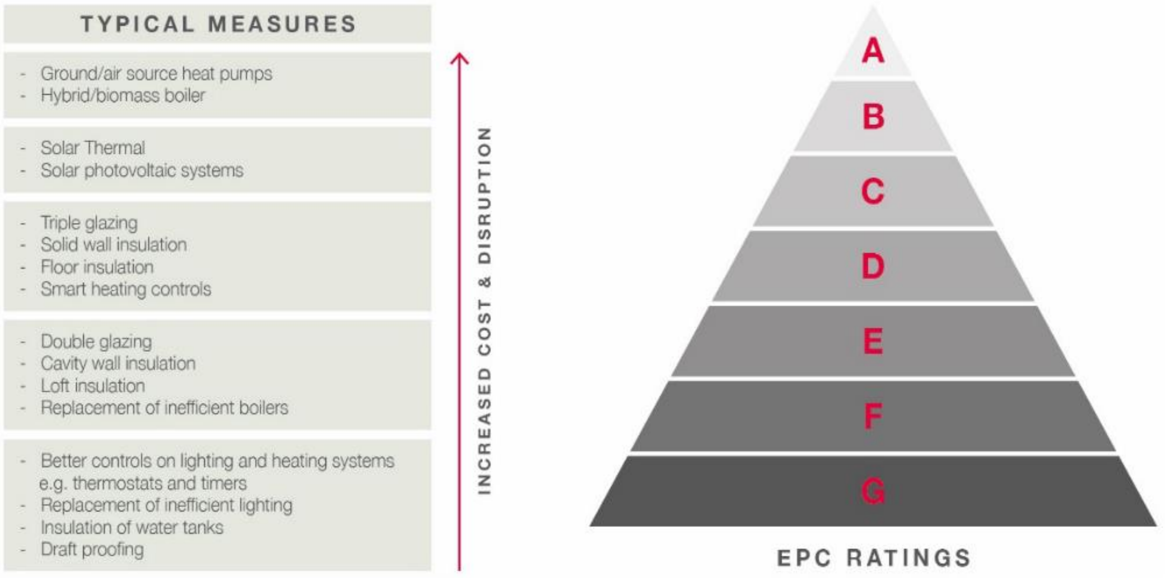
The following figure[11] displays the typical necessary measures to reach an EPC band improvement from the least efficient (G label) to the most efficient (A label). It shows that the technology involved, the level of complexity and necessity for highly skilled work increase as higher energy performance ratings are reached (from replacement of existing lighting at G level to the use of biomass boilers and high value heat pumps to reach A ratings).

[9] RICS, Energy Efficiency and Residential Values: A Changing European Landscape, 2019

[10] EEMI valuation checklist available here: https://eemap.energyefficientmortgages.eu/wp-content/uploads/2018/11/Valuation-and-Energy-Efficiency-Checklist.pdf

[11] Figure taken from the Scottish Government, 2018, National Strategy for an Energy Efficient Scotland https://www.gov.scot/policies/energy-efficiency/energy-efficient-scotland/

Figure 1. Energy Retrofit Typical Measures according to the resulting EPC rating




Source. Energy Efficient Scotland (Scottish Government)

Various studies have investigated energy renovation costs across Europe. Due to the heterogeneity of the building stock and real markets, there are significant differences across Europe in terms of the technical feasibility and financial viability of interventions. A paper from Civel and Elbeze (2016) that it costs an average 430€/m² to reach an EPC B rating (equivalent to a predicted energy consumption between 50 and 90 kWh/m²/year) for a detached house and 165€ m² on average for a multi-apartment building. Another study focussing on the social housing sector[12], shows that for an average renovation cost of 409€/m², the range could span from 137€/m² to 974€/m². This is also due to the fact that energy retrofits are usually combined with non-energy renovation measures and that final renovation costs can be altered by many unexpected and "case by case" factors.

The EEFIG DEEP platform provides key performance indicators (payback time and cost avoidance in Eurocent/kWh) on 5152 energy efficient projects divided into four categories (HVAC, lighting, building fabric measures and integrated renovations). The DEEP platform indicates that the average (median) payback time (years required for the saving to pay for the investment without any interest costs) for all buildings projects is 5,0 years. The avoidance cost (average cost in Eurocent for each kWh energy saved over the lifetime of the measure) for all building projects is 2,5 Eurocent/kWh. It also recognises that the payback time for the same project will vary between countries with differences in energy prices and the public incentive schemes in place (grants, subsidies, risk-sharing and financial instruments).

[12] https://www.union-habitat.org/centre-de-ressources/economie-du-logement/l-investissement-des-organismes-hlm-dans-la-renovation-0.

## 4.3 Energy Efficiency investments as a hedging strategy

A recent study by the European Commission's Joint Research Centre[13] discusses energy efficiency investments from the point of view of a hedging strategy that protect the owner of an energy efficient home or building from specific risks during a low carbon energy transition. The paper argues that energy efficiency investors are less vulnerable to rises in energy prices and suffer less from price volatility as seen for highly financialised commodities such as crude oil prices and secondary energy sources such as electricity. Energy efficiency investments today also safeguard against a more dramatic energy transition that can entail a high proportion of stranded assets in the residential sector. For example, the policy preventing the sale or rent of properties which do not meet minimum energy requirements can have a significant impact on the market value of these assets.

In the above case, energy efficiency investments are made to prevent a future risk that has not yet materialised but might do so in a near future. It is for this reason that the correlation analysis between energy performance and risk cannot be concluded only by looking at one-time snapshots of narrowly defined market segments. Given the proposed standardised data collection framework, EeMAP could have a much broader market penetration as well as a more continuous approach to capturing and monitoring the risk profile of energy efficiency mortgages. Further studies could take a more dynamic approach, e.g. using real options pricing approach, to reflect more accurately the future benefits and risk implications, but also to pick up trends of how the market is responding to energy efficiency related risks.

[13] https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/energy-efficiency-value-buildings-and-payment-default-risk

# 5. Conclusion and recommendations

The present report summarises the results of several empirical and econometric studies investigating the relationship between credit risk and the energy performance of buildings used as collateral in commercial and residential mortgages. Significantly, in many cases, research suggests a correlation between building energy performance and lower credit risk. However, research also points to the fact that, at the same time, a correlation cannot be concluded only by looking at one-time snapshots of narrowly defined market segments.

The proposed standardised data collection framework to be delivered by the second Project under the Energy Efficient Mortgages Initiative, the Energy Efficient Data Protocol & Portal (EeDaPP), will help to develop a more systematic approach to capturing and monitoring the risk profile of energy efficiency mortgages. Further studies could also go a step further and eventually test for causality not just correlation, however this will require longer track record of loan level data and full transparency to the energy performance of assets.

The report concludes that additional factors can impact the credit risk profile and the likeliness of default and, thus, these can strengthen the correlation analysis. First, energy efficiency gains can help to predict savings on future fuel bills and the budget constraint of the borrower. Second, the financial viability of improvement works, as well as the capacity to generate cash flows that would cover the initial upfront cost over a specific timeframe can have an impact on credit risk. Finally, it argues that more investigation needs to be done against the mid- and long-term market and policy developments to fully take into account the value of investing today in energy improvements as a hedging strategy to prevent value erosion from stranded assets under a more ambitious low-carbon energy transition.

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